October 1998

White Paper on

Full Depth Asphalt Pavement

By Daivd A. Friedrichs, Pavement Management Engineer

Background

The technique of "full depth asphalt paving" has recently become popular in some sectors of road construction. This paper discusses the potential use of this application at WisDOT. Wisconsin is blessed with some of the finest quality asphalt roads in the nation. As such, any modification to current practices must show substantial improvements in the quality of the performance of the road or an appreciable reduction in the cost of construction.

The term "full depth asphalt pavement" and "deep strength asphalt pavement" are sometimes confused. For the purpose of this paper, "full depth asphalt pavement" is one where the base course (typically crushed aggregate) is replaced with lifts of asphalt mix (with variable percentage asphalt content). In theory, the pavement derives its strength from the asphalt layers rather than the stone base. A "deep strength asphalt" pavement is one where thick layers of asphalt are used in conjunction with a base course. In Wisconsin, "deep strength asphalt" is not an issue. So long as the life cycle costs are competitive, deep strength asphalt pavement structures are acceptable and can be used on Wisconsin highways.

Experiences to Date

Wisconsin has had very limited experience with this technique. Other states however, have had more experience. The results have been mixed. Illinois, Texas and New Jersey have all had success with the technique, while Minnesota has prohibited their use. The experiences of Minnesota and Illinois have the most applicability to Wisconsin as we share similar climate and soil conditions. The contrast between the two states also provides some enlightenment regarding the disparity in success.

Illinois uses this technique successfully. In their operations, the subgrade is stabilized (usually with lime) to the point where the asphalt paver can be supported. The asphalt layers are then placed over the stabilized subgrade. This has provided a serviceable pavement at reasonable cost. In contrast, Minnesota did not make any appreciable effort to improve the subgrade. In some cases, pavers were not used to place the asphalt lifts. These factors appear to have contributed to the poor performance of roads built with this technique.

Wisconsin does have one notable project where this technique was used. Highway 50 in Delevan, a 4500' urban section, used this technique. The main reason for the effort was to facilitate handling of traffic during construction. From all reports, the technique proved to be highly successful in accommodating traffic to the local businesses. However, it is far to early to reach any conclusions regarding long term performance.

Discussion

There are three basic considerations when evaluating this or any other new technique. The technique must:

- be practical or "buildable"
- be cost effective
- provide equal or greater performance than current practices

If the technique can show positive impacts in these areas when compared to current practices, it should be considered for use.

Practical: In Wisconsin, the highly variable nature of subgrade materials and the poor structural quality of some of those materials would make this technique highly impractical to build and of dubious quality from a performance standpoint unless effort is made to make the subgrade usable. Wisconsin’s situation is very similar to our neighbors in Minnesota and Illinois in this respect. If this technique were to be used, the costs must include nominal subgrade stabilization efforts.

Cost effective: Design of asphalt pavements relies on the relatively simple concept of Structural Number (SN). Once soils support and traffic loading requirements are evaluated, a SN results from the equations. The remainder of the pavement structure (base and pavement layers) must be designed to accommodate a given SN. In its simplest terms each material type is associated with a value of support per inch of thickness. Examples of this are (see FDM14-1-14 Table 4 for a complete list):

- 0.44 for New AC
- 0.10 for crushed gravel base course
- 0.14 for crushed stone base course

For example, 2.5" of AC pavement and 9" of crushed stone base course would provide an SN of 2.5*0.44 + 9.0*0.10 = 2.0.

This implies that there is a direct tradeoff between AC pavement and base course. There are practical limitation on materials (such as minimum layer/lift thickness for AC pavement layers) and geometric design/real estate considerations (each inch of pavement structure equates to 8-12 inches of cross section width because of outslopes), but beyond this, there is no distinction made between materials beyond SN. In essence 4.4" of crushed gravel base course is equivalent to 1" of AC pavement.

The following formula provides a simple guideline for determining the cost effectiveness of this technique:

$$\frac{(\text{AC Cost})*(\text{CABC SN})}{(\text{CABC Cost})*(\text{AC SN})} = X$$

If the ratio (X) is less than one, it is more cost effective to use full depth AC pavement.

For simplicity, the cost of subgrade stabilization has been excluded. This analysis considers only the optimal condition for this technique (on subgrades which wouldn’t require stabilization). For specific designs, these costs would need to be considered.

Current bid prices are approximately $6.00/ton for base course. The equivalent amount of AC material (using 5.5% AC content) is approximately $30.59/ton ($138/ton asphalt * 0.055 + $23/ton aggregate). Therefore, the formula above equates to:

30.59 * 0.10

---------------- = 1.15

6.00 * 0.44

Wisconsin is apparently blessed with inexpensive and readily available sources of aggregate. If the cost of aggregate were more than $6.95 a ton (and this did not translate into increased AC aggregate costs) the full depth AC pavement option becomes the more cost effective solution. However, the considerations (and costs) of subgrade stabilization must also play into the equation.

In the case of Illinois, costs for aggregate are $8-9.00/ton and total asphalt costs are $34-36.00/ton (data from David Lippert, IDOT). Even using the most extreme values, Illinois breaks even on the cost of using full depth asphalt.

Illinois numbers:

36.0 * 0.10

------------------ = 1.02 (Note, midpoint value is 0.93, low is 0.85)

8.00 * 0.44

As an alternative to placing an asphalt pavement directly on the subgrade, some sort of highbred design could be attempted. Current practice indicates that 5.5% asphalt is typically used in design of an asphalt pavement. A stabilized base course uses approximately 2.5% oil as a minimum. There is no reason why some value between these two limits could not be used. For lack of a better term, these "lean" asphalt pavements would provide a SN somewhere between 0.10 and 0.44. Regrettably, there is no hard evidence to base decisions on. If a structural number for these "lean" asphalt structures could be determined, the formula above could be used to determine an cost effective solution.

Performance: In theory, all pavement designs which have the same structural number should perform at an equal level so long as all other considerations (environment, traffic loading, etc.) are equal. In reality this is often not the case.

Minnesota used a highly dubious technique of blading the AC material onto a substandard subgrade. In all likelihood, this destroyed the integrity of the material (provided a less than expected SN). This is the probable reason for the failure of the method in this case.

Illinois took the time to stabilize the subgrade (which in turn reduces the required SN for the pavement structure). This coupled with their more costly aggregate makes the technique usable and cost effective and performance is not hindered because sound practices in design and construction are followed.

In general, there is very little hard evidence of long term performance. The technique has been in use in many low performance requirement applications (urban streets, parking lots, subdivisions, etc.) and its use is limited in higher level facilities. There are several areas of concern (possible stripping of bottom AC layers with no base for example) but there is no evidence to indicate that performance should not be excellent so long as sound design and construction principles are followed.

Summary

The technique of full depth asphalt pavement has the following characteristics:

- Cost issues indicate that so long as inexpensive aggregates are available, this is not a cost-effective solution
- Good performance is a reasonable expectation so long as sound design and construction practices are adhered to.
- Traffic can be accommodated once the first lift is placed on the subgrade providing greater flexibility in staged construction.
- Construction is possible and practical if adequate subgrade is in place or can be constructed with stabilization.
- Experience is limited in Wisconsin
- There is no experience in Wisconsin for variable levels of AC content which may be more cost effective

Recommendations

The technique of full depth asphalt pavement should be considered for use in areas where one or more of the following conditions exist:

- aggregate costs (transport and material) are high
- geometric considerations require thin pavement structure
- traffic control considerations require driving surfaces quickly

A long term pavement evaluation demonstration project should be started to assess the relative merits of "lean" AC pavement structures and to determine the relative SN of asphalt pavements where AC contents between 2.5% and 5.5% are used. Ideally the project should be on a road with moderate heavy truck traffic and be at least 5 miles long (five one-mile sections). The sections include:

Control #1: "normal" AC pavement on base (base with 5.5% AC surface course)

Test #1: 2.5% "lean" AC base instead of "normal" base

Test #2: 3.5% "lean" AC base instead of "normal" base

Test #3: 4.5% "lean" AC base instead of "normal" base

Test #4: "normal" AC pavement with no base

: